Lab 5 Report

ECE 332 Winter 2020

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1 Introduction

In this lab, we were introduced to the concepts of Variable Speed Drive (VSD), Variable Frequency Drive (VFD), and Adjustable Speed Drive. Our main objective for this lab was to implement a Variable Frequency Drive in order to control our induction motor. We first started this lab by implementing an open-loop version of the controller and then moved to a closed-loop version of the motor driver. After this, we tuned the controller so that it was able to respond to a step response within certain specifications.

2 Methods

2.1 Hardware

The hardware was connected identically as in the last lab. Figure 1 shows the board to which we connected the motor to.

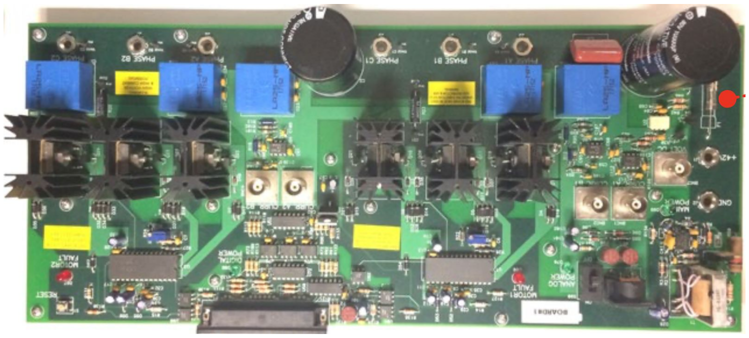

Figure 1. Controlling board for motor

The board was connected to the power supply that supplied the motor power. Additionally, it had another power supply that powered the logic on the board itself. This power supply is shown in Figure 2.

Figure 2. Power supply for logic on controlling board.

The three-phase ac induction motor was powered by 42 VDC from the power supply through an active bridge inverter in the board and output a three-phase sinusoidal PWM signal to create the rotating magnetic field required to control the speed of the motor.

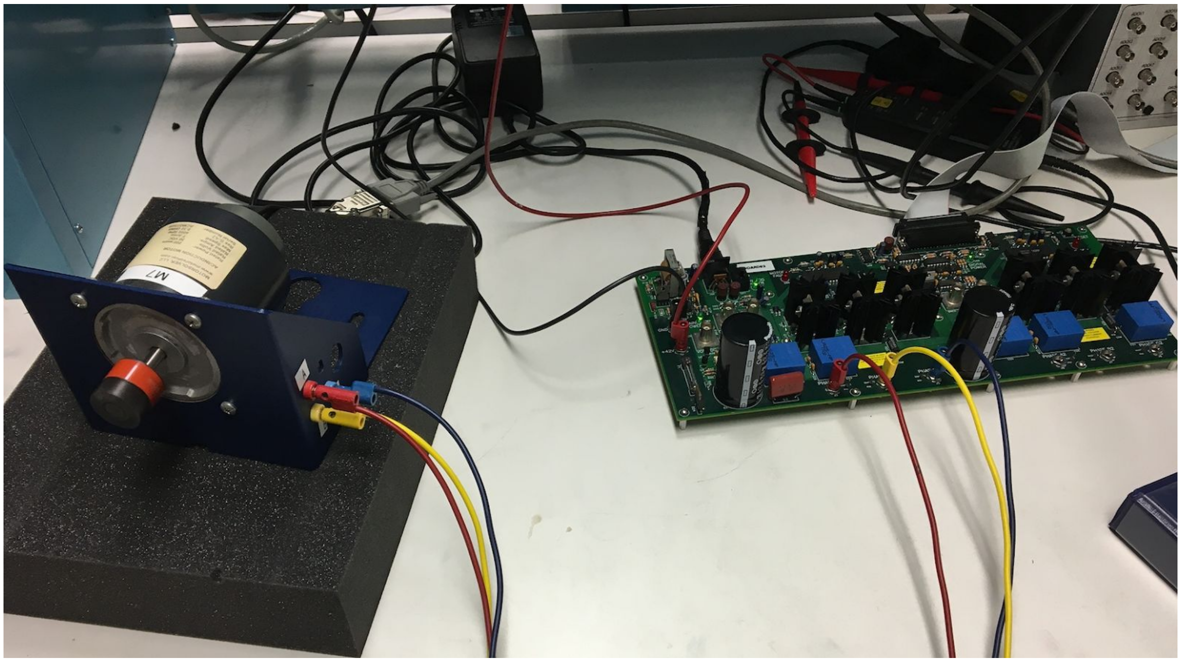

Figure 3. Experimental set-up.

2.2 Programming

As in our last labs, we reused code from Lab 3. More specifically, we reused the averaging block. This system’s main goal is to return the average RPM and the displacement of the motor. We are only really interested in the RPM. An image of this design can be seen in Figure 3.

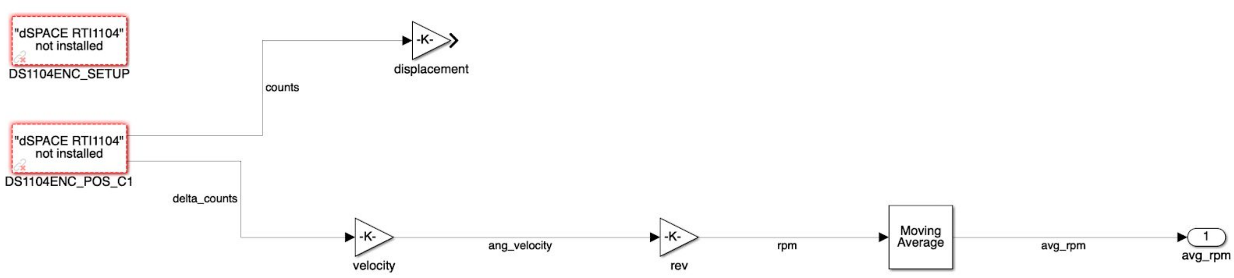

Figure 3. Averaging block that returns average RPM and displacement of the motor.

In addition to this code, we also reused the variable frequency block from lab 4. This design's main focus is to be able to take an input, the frequency constant, and update the controlling wave that is being fed into the three separate PWM signals being sent to each phase of the motor A, B, and C. Although most of this block was reused we had to change some things. Instead of having a single input to this whole block we now have two inputs, frequency and amplitude modulation.

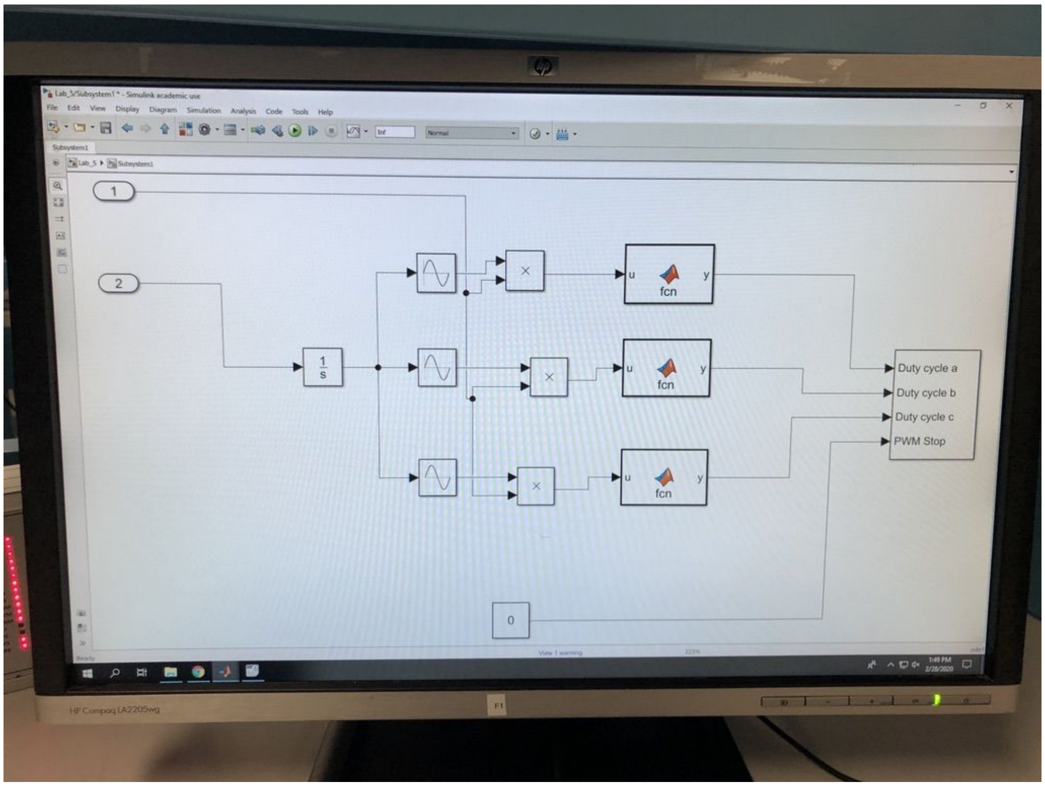

Figure 4. The variable-frequency design that controls the motor speed. This was implemented in Simulink.

When the Variable frequency part was integrated with the rest of the system, it looked like figure 5.

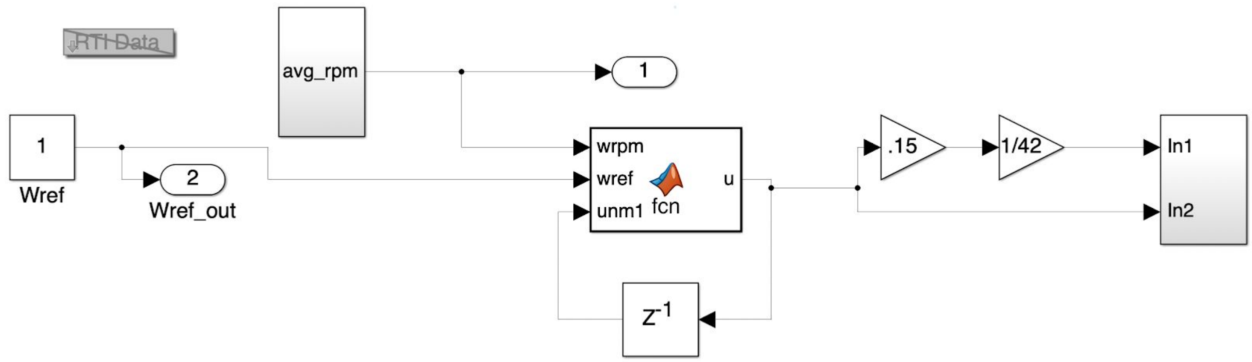

Figure 5. Entire Lab 5 Simulink design of the Variable Frequency Drive in closed-loop.

The only variable parameter in the closed-loop system was the reference speed at which we wanted the motor to rotate. The closed-loop functionality of the design would make sure it reached the target speed and try to maintain it as close as possible. The code in the function block is displayed in figure 6.

```
function u = fcn(wrpm,wref, unm1)

x = (wref -wrpm)+17.5;
if x>1
    if x>50
       u = unm1+0.01;
    else
       u = unm1+0.0001;
    end
elseif x<1
    if x<50
       u = unm1-0.01;
    else
       u = unm1-0.0001;
    end
else
    u = unm1;
end

if u>=128
    u=127;
elseif u<=0
    u=1;
end

end
```

Figure 6. Matlab code that bounds the output to the phase controller

The code is able to show that fine-tuning happens in two areas. If the error between the reference speed and actual speed is greater than 50, then the driver tries to compensate for this discrepancy quickly. If the error is less than one, then the error is small and the changes in the output should follow in the same manner, they should be minor changes so that there is not a large variation at the output. Lastly, it bounds the output between 128 and 0. If the value is increasing and it exceeds the value of 128, the system will stop increasing the value at 127. Similarly, if the value is going negative, which is not allowed, it will set the minimum at 1 so that the value is the expected range.

After the function block described in figure 6, there are some gain terms meant to optimize the values passed to the phase controller in order to optimize the output of the motor.

3 Results

As required for this lab, the motor speed was to match that of the reference speed within 1 second when changing the reference speed from 1000 RPM to 1200 RPM, as well as fluctuate no more than ± 15 RPM. We were successfully able to do this by changing the amount the speed increases depending on the difference between the actual and reference speed. This allowed the motor to accelerate fast enough to be within the 1-second acceleration requirement. To minimize the speed fluctuations, the motor would make small adjustments while the speed was only slightly off the reference speed.

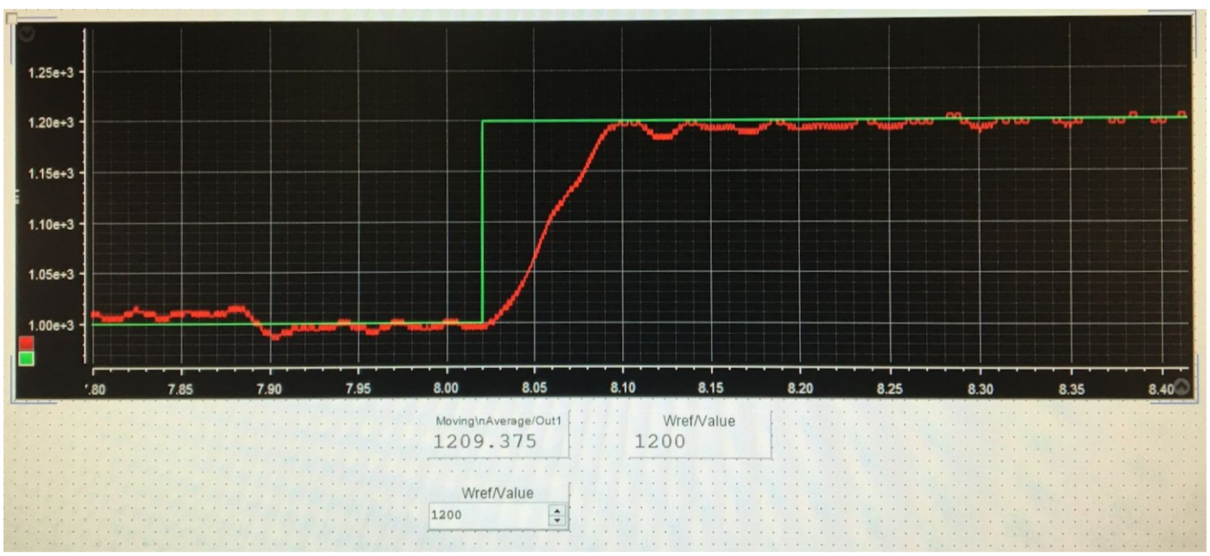

Figure 7. Graph showing the motor speed reaching a steady-state value matching that of the reference angle in less than 1 second. The speed first reaches that of the reference speed in than 0.1 seconds, and stabilizes within 0.35 seconds.

Figure 8. Graph displaying the steady-state motor speed fluctuations. As can be seen, the maximum fluctuation is -14 RPM, which is within the maximum range of ± 15 RPM

4 Discussion

For this lab, we successfully implemented a well-defined three-phase AC variable frequency drive for an induction motor. The motor behaved much like the design from the previous lab, with the added inclusion of extending the open-loop operation into a closed-loop system and expanding on the Matlab function block to allow the motor to operate within the design parameters. Possible improvements to the design could be expanding on the function and fine-tuning the step values to increase the response time, as well as maintain more consistent steady-state operation